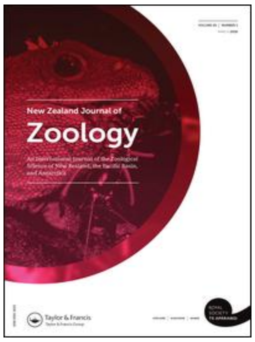

New Zealand Journal of Zoology

ISSN: 0301-4223 (Print) 1175-8821 (Online) Journal homepage: http://www.tandfonline.com/loi/tnzz20

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To cite this article: Jorge Pérez-Schultheiss, Karina Ayala, José Miguel Fariña & Cristina Coccia (2018): Exotic oniscideans (Crustacea: Isopoda) in coastal salt marshes: first record of the families Halophilosciidae and Platyarthridae in Continental Chile, New Zealand Journal of Zoology, DOI: 10.1080/03014223.2018.1539017

To link to this article: https://doi.org/10.1080/03014223.2018.1539017

Published online: 29 Oct 2018.

NEW ZEALAND JOURNAL OF ZOOLOGY
https://doi.org/10.1080/03014223.2018.1539017

RESEARCH ARTICLE

Exotic oniscideans (Crustacea: Isopoda) in coastal salt marshes: first record of the families Halophilosciidae and Platyarthridae in Continental Chile

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ABSTRACT
We report two new exotic introduced isopods in Chile: *Halophiloscia couchii* of the family Halophilosciidae and *Niambia capensis* of the family Platyarthridae. This report provides first evidence of the presence of these species in the Southeastern Pacific. These species were found in several salt marshes and beaches spanning nearly 2000 km of the Chilean coast. With the data reported here, the percentage of exotic oniscidean isopods in Chile is 28%.

ARTICLE HISTORY
Received 29 July 2018
Accepted 18 October 2018

ASSOCIATE EDITOR
Jonathan Banks

KEYWORDS
Oniscidea; exotic; new records; salt marshes; South America

Introduction

Oniscidean isopods have been reported in almost all terrestrial ecosystems, in a number of variable habitats, including the supra-littoral zone of coastal areas. In many salt marsh ecosystems they can reach exceptionally high abundances, showing their ability to exploit these highly productive but very stressful habitats. Oniscidean in salt marshes constitute the dominant component of the detritivore community (Zimmer et al. 2002; Dias et al. 2005) and participate in several ecosystem functions, including nutrient cycling (Khemaissia et al. 2013, 2017). Moreover, they can serve as indicators of environmental conditions. For example, the absence of oniscideans in highly acidic and contaminated soils has led them to be indicators of these conditions (Paoletti and Hassall 1999; Souty-Grosset et al. 2005).

In Chile (including Easter Island), published studies of Oniscidea reported 13 families and 41 species (Pérez-Schultheiss 2009; Taiti and Wynne 2015). Among these, 10 species in four families (Oniscidae, Armadillidiidae, Porcellionidae and Platyarthridae) are considered as exotic and synanthropic.

Exotic invasive species are considered as one of the leading causes of native species extinction worldwide (Gurevitch and Padilla 2004) but in some cases, native and exotic species can co-exist (Vilisics and Hornung 2009; Tanaka and Karasawa 2018). Chile has been subjected to invasion by a variety of plant, vertebrate and insect taxa (Peña et al. 1975; Jaksic et al. 2002; Jaksic and Castro 2014; Fariña and Camaño 2017). Most of these invaders have dramatically affected the invaded ecosystems (Aizen et al. 2018; Tadich et al. 2018). In salt

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marshes, the incomplete inventory of arthropods, including oniscideans, makes it difficult to understand the potential risk that invasive species posed to the conservation of native/endemic species (Wynne et al. 2014; Taiti and Wynne 2015).

Our objective in the present study was to provide diagnostic information for the identification of two exotic oniscidean isopods recorded for the first time in Chile, during a study investigating the species composition and abundance of arthropods living in salt marshes spanning approximately 2000 km of the Chilean coast.

Material and methods

Sampling was conducted in nine salt marshes along the Chilean coast, from the Atacama to Los Lagos Region (Table 1 and Figure 1). These localities were selected because they have not been severely modified by urbanisation or agricultural activities. The salt marshes are distributed across different climate types, including hyper-arid (coast of Atacama Desert in Las Salinas and Carrizal Bajo), arid (El Litre and Pachingo), semi-arid (Conchalí Pullally and El Yali), humid (Carampangue), and hyper-humid (Putemum, located on the protected coastline of Chiloe Island and subject to some of the largest tides in Chile).

The oniscidean isopods were collected twice during austral autumn and spring 2016 using pitfall traps distributed over the high marsh zone to avoid inundation. Each trap consisted of two plastic cups (each of 9 cm diameter and 12.5 cm deep) inserted one inside of the other in the ground and partly filled with a 50% ethylene glycol and 50% water solution as a preservative. The traps were emptied after 72 h. In the laboratory, samples were first washed and sieved (250-µm mesh), then sorted and preserved in 70% ethanol. We also examined specimens of the studied species previously collected in the supralittoral zone of two sandy beaches located in the Valparaiso and Coquimbo Regions (Table 1). These specimens were obtained from the collections of the National Museum of Natural History, Chile. This material is included as additional records.

Specimens were first dissected under an Amscope SF-2TRA stereoscope and then individual appendages were slide mounted on glycerol and studied using an Amscope T490A microscope at 40X-100X magnification. Photographs of the entire specimens and their morphological details were acquired with a Nikon D5500 digital camera adapted for the stereoscope and optic microscope. For this, the software CombineZP was used, and plates were prepared with Adobe Photoshop. Morphological diagnostic characters of each appendage were compared to taxonomic keys and to available literature (Barnard 1932; Miller 1936; Vandel 1962; Schultz et al. 1982; Cruz-Suarez 1992; Brusca et al. 2007; Noël and Séchet 2007).

Diagnoses included characters for discrimination at family, genus, and species level and considering all the known oniscidean species in Chile. Additional diagnostic characters for discrimination of related genera are discussed in the Remarks section. All material, including specimens and dissections, has been deposited in the isopod collection of the Museo Nacional de Historia Natural, Chile (MNHNCL ISO).

Results

Order Isopoda, Latreille 1817

Table 1. List of the oniscidean species in the studied sites. Asterisks indicate the two studied beaches.

Locality	Geographic coordinate	Habitat	*Halophiloscia couchii*	*Niambia capensis*	*Benthanoides* sp.	*Porcellio scaber*	*Porcellio laevis*	*Porcellionides sexfasciatus*	*Scyphoniscus* sp.	*Styloniscus* sp.	*Ligia* sp.	*Tylos chilensis*
Las Salinas[1]	27°17′47.44″S 70°55′55.60″W	*Sarcocornia fruticosa*		X	X				X			
Carrizal Bajo[1]	28°4′59.9″S 71°8′38.64″W	*Sarcocornia fruticosa*		X	X				X			
El Litre[1]	30°17′49.10″S 71°32′21.10″W	*Sarcocornia fruticosa*	X	X	X				X			X
Pachingo[1]	30°18′10.7″S 71°34′26.75″W	*Sarcocornia fruticosa*	X	X	X							X
Chigualoco*	31°45′32.9″S 71°30′26.6″W	Under stones		X	X							
Conchali	31°52′39.95″S 71°29′47.5″W	*Sarcocornia fruticosa*		X	X	X						
Pullally[1]	32°55′10.17″S 71°30′28.98″W	*Spartina densiflora*			X				X			X
Cochoa*	32°57′20.58″S 71°32′50.19″W	Under stones	X				X	X			X	
El Yali	33°45′23″S 71°43′30″W	*Spartina densiflora*		X	X				X			
Carampangue	37°14′9.56″S 73°18′11.21″W	*Spartina densiflora*		X	X	X						
Putemun[1]	42°29′33.60″S 73°45′5.25″W	*Spartina densiflora*								X		

[1] Author's unpublished data.

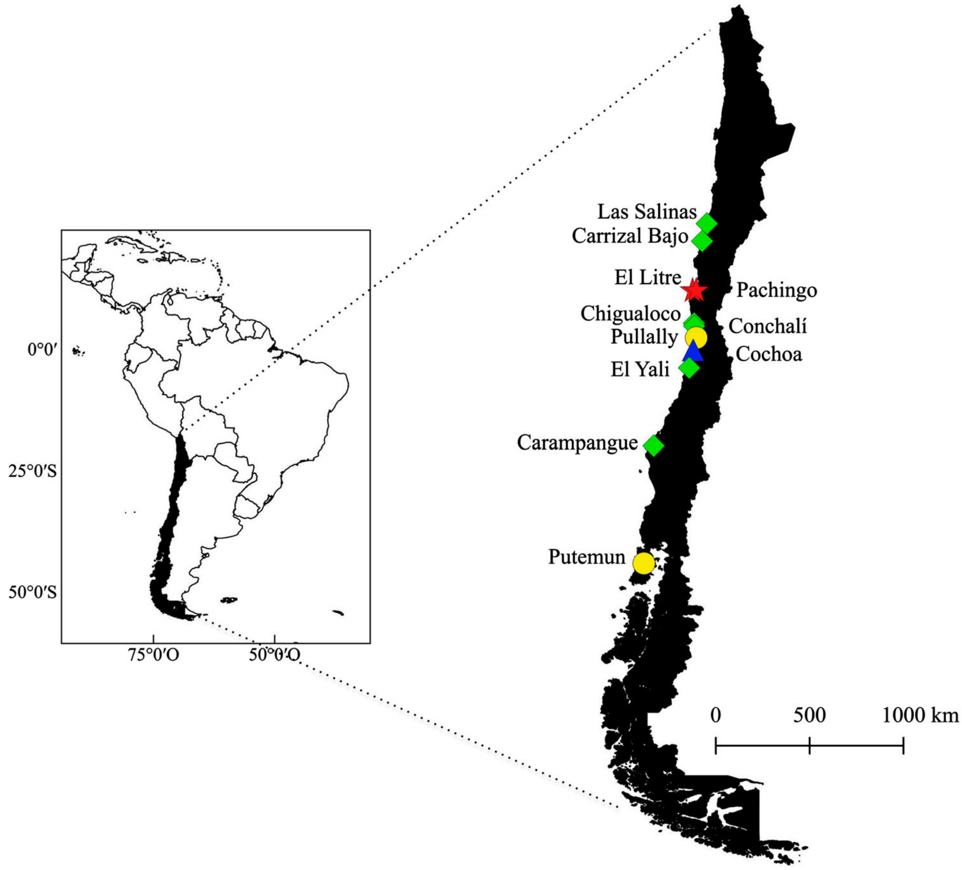

Figure 1. Map of the sampling sites in Chile. Diamonds identify salt marshes with *Niambia capensis*; triangle identifies salt marshes with *Halophiloscia couchii;* stars identify salt marshes where both species co-exist; circles represent species not collected.

Suborder Oniscidea, Latreille 1802
Section Crinocheta, Legrand 1946
Superfamily Oniscoidea, Latreille 1802
Family Halophilosciidae Verhoeff 1908

Halophiloscia couchii (Kinahan 1858)

(Figure 2)

Philoscia couchii Kinahan 1858, 195, pl. 23, fig. 4.

Halophiloscia couchii Vandel 1962, 477–480, figs. 237–238; Cruz-Suarez 1992, 115–117, fig. 2; Rodríguez and Barrientos 1993, 184–185, figs. 1–7; Schmidt 2003, 15–22, figs. 52–57.

Diagnosis: Crinocheta without conglobation ability. General appearance of philosciid, with pereonal lateral outline convex, tergites smooth and pleon abruptly narrowed in relation to pereon (Figure 2(A)). Antennae long with 3 flagellar articles, surpassing pereonite 4 if directed backward (Figure 2(A, C)). Carpus and propodus in the first two pereopods inflated in males (Figure 2(B)). Endopodite of the male pleopod 1-2 with distal part widened (Figure 2(D)). Genital papilla bifurcate distally. Exopodite of uropod three times

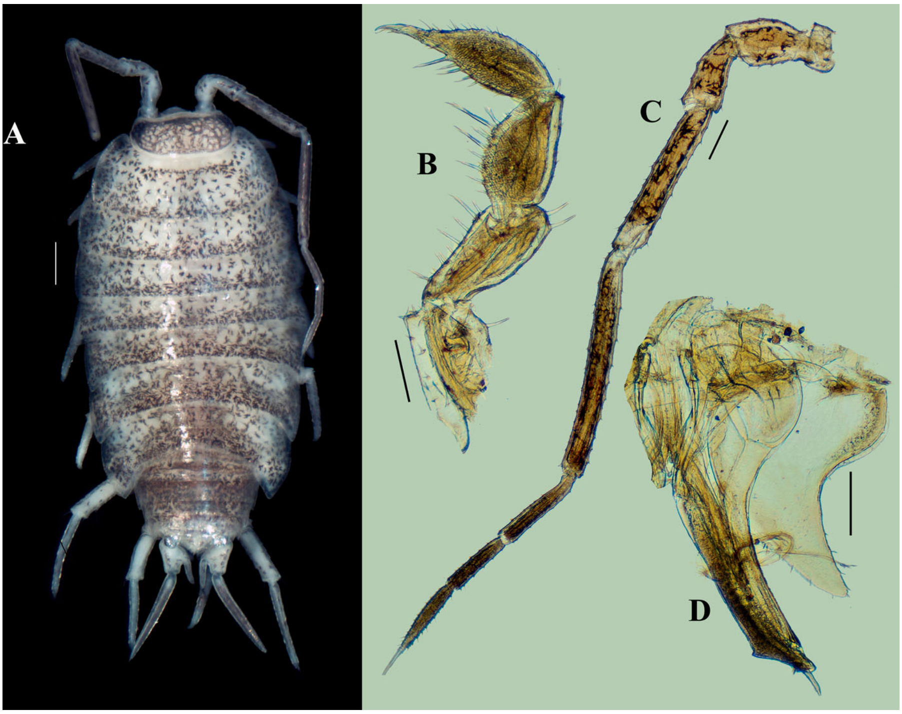

Figure 2. *Halophilosciia couchii*: A, Habitus of male. B, Male pereopod 1, from isquium to dactylus. C, Antenna. D, Male pleopod 1. Scales: Figure A = 0.5 mm; Figures B–E = 0.2 mm.

longer than peduncle; endopodite short, reaching only the proximal part of exopodite, inserted markedly more proximal than exopodite (Figure 2(A)).

Material examined: 5 males and 7 females (MNHNCL ISO-15052), Pachingo, La Serena, Región de Coquimbo, 30°18′10.7″S, 71°34′26.75″W, 14-X-2016, Col. C. Coccia, Pitfall traps, *Sarcocornia fruticosa* 4 males and 4 females (MNHNCL ISO-15053), El Litre, Región de Coquimbo, 30°17′49.1″S, 71°32′21.1″W, 14-X-2016, Col. C. Coccia, Pitfall traps, *Sarcocornia fruticosa* 2 females (MNHNCL ISO-15054), El Litre, Región de Coquimbo, 30°17′49.1″S, 71°32′21.1″W, 23-V-2016, Col. C. Coccia, Pitfall traps, *Sarcocornia fruticosa* 1 male and 1 female (MNHNCL ISO-15068), Playa Cochoa, Región de Valparaíso, 32°57′20.58″S 71°32′50.19″W, 19-X-2017, Col. J. Pérez-Schultheiss and K. Ayala, Vertiente supramareal, JP-274.

Distribution: This species is native to the Atlantic coasts of Europe, but it has also been recorded as an alien species in USA, Bermuda, Brazil, Argentina, and Australia (Leistikow and Wägele 1999; Poore 2005). In Chile, it was collected in only two salt marshes and one sandy beach between 30° and 32° S (Table 1). The diagnostic characters are in agreement with Rodríguez and Barrientos (1993) and Schmidt (2003).

Remarks: *H. couchi* can be recognised among the other species of *Halophiloscia* by the structure of the endopod of male pleopods 1-2. In pleopod 1, the endopod has a straight lateral margin; the medial margin has a subdistal cone shaped lobe and a rounded distal lobe with an adjoined slender tip. In the endopod of pleopod 2, the medial subdistal margin has a convex lobe.

Family Platyarthridae, Verhoeff 1949

Niambia capensis *(Dollfus 1895)*

(Figure 3)

Metoponorthus capensis Dollfus 1895, 350, fig. 9.

Niambia capensis Budde-Lund 1904, 37; Barnard 1932, 266–368, fig. 23k–n, 24c–I.

Mauritaniscus littorinus Schultz et al. 1982, 78–82, figs. 1A–O, 2A–N.

Porcellio littorina Miller 1936, 168, figs. 3, 7, 14, 15, 19.

Diagnosis: Crinocheta without conglobation ability; general appearance of a small *Porcellionides*, with pleon slightly narrowed in relation to pereon and dorsal surface covered with small scale-setae, more prominent in head, margin of segments and pleotelson (Figure 3(A)). Antenna normal, reaching the second pereonite and with two flagellar articles, 1st shortest; 2nd longest (Figure 3(B)). Posterolateral margin of pereonites 1-3 convex (Figure 3(A)). Carpus and propodus of the first two pereopods not inflated in males (Figure 3(C)); merus of male pereopod 7 with a small lobe at the base of the sternal margin (Figure 3(F)). Endopodite of pleopods 1-2 with sharp apex. Genital papilla not bifurcated distally. Exopodite of male pleopod 1 cordiform, with a dentiform projection in the outer margin (Figure 3(D)). Uropod exopodite longer than peduncle; endopodite exceeding half the length of exopodite, inserted more proximally than exopodite (Figure 3(A)).

Material examined: 2 females (MNHNCL ISO-15055), El Yali, Santo Domingo, Región de Valparaíso, 33°45′23″S, 71°43′30″W, 24-IX-2016, Col. C. Coccia, Pitfall traps, *Spartina densiflora* 1 male (MNHNCL ISO-15056), El Yali, Santo Domingo, Región de Valparaíso, 33°45′23″S, 71°43′30″W, 24-IX-2016, Col. C. Coccia, Pitfall traps, *Spartina densiflora* 2

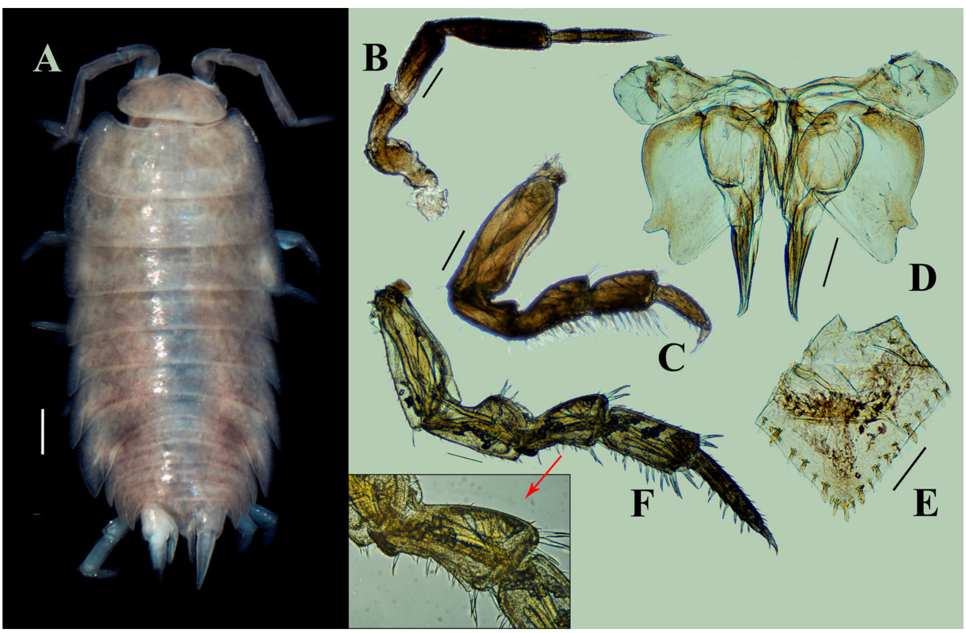

Figure 3. *Niambia capensis*: A, Habitus of male. B, Antenna. C, Male pereopod 1. D, Male pleopod 1 and genital papilla. E, Telson distal section, showing the setae-scales. F, male pereopod 7, showing detail in merus. Scales: Figure A = 0.5 mm; Figures B–D and F = 0.2 mm; Figure E = 0.1 mm.

males and 1 female (MNHNCL ISO-15057), Carrizal Bajo, Huasco, Región de Atacama, 28°4'’59.9″S, 71°8'’38.64″W, 15-X-2016, Col. C. Coccia, Pitfall traps *Sarcocornia fruticosa* 4 males and 4 females (MNHNCL ISO-15058), Carampangue, Arauco, Región del Biobío, 37°14′9.56″S, 73°18′11.21″W, 11-XI-2016, Col. C. Coccia, Pitfall traps, *Spartina densiflora* 1 males and 1 females (MNHNCL ISO-15059), Carampangue, Arauco, Región del Biobío, 37°14′9.56″S, 73°18′11.21″W, V-2016, Col. C. Coccia, Pitfall traps, *Spartina densiflora* 4 males and 6 females (MNHNCL ISO-15060), Pachingo, La Serena, Región de Coquimbo, 30°18′10.7″S, 71°34′26.75″W, 14-X-2016, Col. C. Coccia, Pitfall traps, *Sarcocornia fruticosa* 1 female (MNHNCL ISO-15061), Pachingo, La Serena, Región de Coquimbo, 30°18′10.7″S, 71°34′26.75″W, 23-V-2016, Col. C. Coccia, Pitfall traps, *Sarcocornia fruticosa* 4 males and 5 females (MNHNCL ISO-15062), Las Salinas, Copiapó, Región de Atacama, 27°17′47.44″S, 70°55′55.60″W, 15-X-2016, Col. C. Coccia, Pitfall traps, *Sarcocornia fruticosa* 1 female (MNHNCL ISO-15063), Las Salinas, Copiapó, Región de Atacama. 27°17′47.44″S, 70°55′55.60″W, 24-V-2016, Col. C. Coccia, Pitfall traps, *Sarcocornia fruticosa* 3 males and 4 females (MNHNCL ISO-15064), El Litre, Región de Coquimbo, 30°17′49.1″S, 71°32′21.1″W, 14-X-2016, Col. C. Coccia, Pitfall traps, *Sarcocornia fruticosa* 1 female (MNHNCL ISO-15065), Las Salinas, Copiapó, Región de Atacama, 27°17′47.44″S, 70°55′55.60″W, 15-X-2016, Col. C. Coccia, Pitfall traps, *Sarcocornia fruticosa* 1 female (MNHNCL ISO-15066), Laguna Conchalí, Región de Coquimbo, 31°53′S, 71°30′W, 29-IX-2016, Col. C. Coccia, Pitfall trap. 10 males and 23 females (MNHNCL ISO-15067), Playa Chigualoco, Los Vilos, Región de Coquimbo, 31°45′32.9″S, 71°30′26.6″W, Col. J. Pérez-Schultheiss, Bajo piedras, supramareal, JP-295.

Distribution: *Niambia capensis* is originally distributed in Namibia and South Africa (Vandel 1977) and recorded as an alien species in Saint Helena Island (South Atlantic Ocean-UK) and along the West coast of North America from southern Washington to southern California (Vandel 1977; Schultz et al. 1982). In Chile, *N. capensis* has been collected in seven salt marshes and one sandy beach from the Atacama to the Biobio Region (Table 1).

Remarks: *Niambia capensis* has been frequently confused with a Porcellionidae due to the biarticulated antennal flagella and the absence of conglobation ability (eg Miller 1936). However, it can be differentiated by the absence of lungs in pleopods, by the absence of the small cone-shaped process in the anteroventral part of coxae 2-4, and by the presence of conspicuous scale-setae in the dorsal surface of the body (Schmidt 2003; Figure 3(D, E)).

Discussion

In this study we found that *N. capensis* is widely distributed along the Chilean coast, whereas *H. couchii* appears to have a narrower distribution (Figure 1). Both species coexisted with several native and exotic species (Table 1) in both salt marshes and sandy beaches.

The genus *Niambia* includes 22 species, distributed in Africa and the Atlantic islands (Schmalfuss 2003; Taiti and Ferrara 2004), and two have been reported as introduced species in America. *N. capensis* is originally described as from Cape Town, South Africa (Dollfus 1895). Later, it has been cited from Saint Helena Island and the west coast of North America, where apparently it has been introduced (Vandel 1977; Schultz et al.

1982). The specimens here studied, represent the first record of *N. capensis* from the southeastern Pacific coast of South America. This species was recorded from seven of the nine salt marshes studied (Table 1) and from the high part of beaches in central and southern Chile, from 27° to 37° S.

The genus *Halophiloscia* includes nine species distributed in Europe and North Africa (Schmalfuss 2003; Taiti and López 2008; Taiti and Argano 2009; Campos-Filho et al. 2015). Most of these species have restricted distributions (Bidegaray-Batista et al. 2015), while only *H. couchii* is frequently found as an alien species outside its native area.

Halophiloscia couchii is originally distributed along the coast of the Mediterranean and along the Atlantic sides of Africa and Europe (Vandel 1962). However, this species has been recorded as an alien species in the Americas, Hawaii, and Australia (Leistikow and Wägele 1999). In the Americas, it has been recorded from several areas of the Pacific coast of North and Central America, and from Brazil (Lemos de Castro 1958) and Argentina (Reca 1972). This is the first record of *H. couchii* from the Pacific Coast of South America. It occurs in salt marshes and in the high part of beaches located between 30° and 32° S.

With these new records, the Chilean Oniscidea now includes six exotic families and 12 exotic species. However, among these species, only seven species (*Porcellio scaber*, *Porcellio dilatatum, Porcellio laevis*, *Porcellionides pruinosus*, *Armadillidium vulgare, Trichorhina tomentosa* and *Venezillo parvus*) have been confirmed by actual specimens reported in the literature (see Wahrberg 1922; Strouhal 1961; Taiti and Wynne 2015), while the other three species (*Oniscus asellus*, *Porcellionides sexfasciatus* and *Armadillidium nasatum*) have been mentioned only as cosmopolitan (Berrios and Sielfeld 2000), without reference to localities or specimens collected in Chile. Nevertheless, the presence of *P. sexfaciatus* in Chile is confirmed in the present study.

In general, exotic oniscidean isopods have been frequently associated with anthropically disturbed zones (Hornung et al. 2007). However, as observed in this study, they also represent an important component of the oniscofauna of less disturbed sites. Although exotic isopods can coexist with some native species (Vilisics and Hornung 2009), we have no information about the type of interactions occurring between native and invasive species recorded in this study. For example, it is yet unknown whether competition occurs between the exotic and the native rare or undescribed species here reported (eg *Styloniscus* sp. and *Scyphoniscus* sp.). It is likely that *Styloniscus* sp. and *Scyphoniscus* sp would have a lower competitive ability than most common species. In this sense, knowing the distribution of exotic oniscidean isopods is necessary to assess their potential impacts on the ecology of natural areas.

Acknowledgements

JPS is grateful to Francisco Urra and Guillermo Valenzuela, for their support during the field trip to Chigualoco. We also thank the Basal fund of CONICYT (FB0002-2014) and the Center of Applied Ecology and Sustainability- CAPES.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by CONICYT/FONDECYT postdoctoral grant N°3160330 to CC and Regular project N°1141117 to JMF; and by the Dirección de Bibliotecas Archivos y Museos (Ministerio de Educación, Gobierno de Chile) under grant FAIP-N-73-EST to JPS.

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